

A Blessing in Disguise: The Long-Term Effects of Childhood Exposure to the Boll Weevil on Old-Age Longevity*

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Abstract

The infamous agricultural pest, the boll weevil, spread across southern US counties between 1892 and 1920. It had devastating impacts on cotton production, a highly child-labor-intensive crop. This study examines how the arrival of the boll weevil and the subsequent reductions in child labor affect later-life mortality outcomes. Using Social Security Administration death records linked with the 1940 census, we document that the staggered spread of the boll weevil improved the longevity of exposed male children. Full exposure to the boll weevil is associated with an intent-to-treat effect of 1.1 months of higher longevity. We show that the estimated effects are robust across a wide array of specifications, are not driven by sociodemographic and socioeconomic compositional change in the final sample, and are not associated with pre-existing trends in the outcome. Further, we find larger impacts among Blacks, children of lower educated mothers, whose fathers work in the farming industry, and those born in high cotton intensity counties. Moreover, the effects appear to be substantially larger among children in states with less restrictive child labor policies, implying the role of these policies in reducing the adverse effects of child labor in the absence of the boll weevil in cotton production counties. Affected children are more likely to migrate, and their destination counties are more likely to be urban and have higher socioeconomic scores. The 1940 census suggests that the exposed children attain higher levels of education and have higher socioeconomic scores. We discuss the policy implications of these results in relation to child labor and school attendance policies in developing countries.

Keywords: Mortality, Longevity, boll weevil, Agricultural Shocks, Child Labor, Education

JEL Codes: I18, J18, N51, N52, Q19

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1. Introduction

A recently growing literature investigates determinants of disparities in aging and longevity and documents the influence of early life and childhood conditions and exposures (Aizer et al., 2016; Barker, 1992, 1994, 1995; Hayward & Gorman, 2004; Lindeboom et al., 2010; Myrskylä, 2010). Shocks in early life and childhood change the trajectory of developmental outcomes and can be detected in later-life health and longevity. For instance, one prominent line of research examines the effects of quantity and quality of education on later-life health and mortality and finds neutral (Albouy & Lequien, 2009; Meghir et al., 2018) or positive impacts (Buckles et al., 2016; Lleras-Muney, 2005; Lleras-Muney et al., 2022). Another line of research investigates the influence of family socioeconomic conditions, parental job loss, and worsening local economic conditions and documents negative consequences on an array of later-life outcomes, including mortality and longevity (Hayward & Gorman, 2004; Noghanibehambari et al., 2024; Scholte et al., 2015; Van Den Berg et al., 2006). However, many exposures are multifaceted and affect children's outcomes in several ways. For instance, negative demand-side shocks in local labor markets have a negative impact on household financial resources, meanwhile incentivizing migration to better places, which might turn out to be advantageous for children's outcomes in the short-run and long-run (Black, Sanders, et al., 2015; Finkelstein et al., 2021). Further, such negative shocks to local labor markets, specifically informal labor markets that employ children as low-wage workers, might incentivize parents to invest in children's schooling by lowering the opportunity cost of school attendance (Duryea & Arends-Kuenning, 2003).

The current study joins this literature by evaluating a unique and arguably exogenous agricultural labor market shock. Specifically, we focus on the cotton production sector in the early

decades of the 20th century in the US South. In this period, the cotton harvest required a significant influx of additional labor from September to December. Due to their small size and nimble fingers, children were often hired, both officially and unofficially, to meet the high demand for seasonal workers. The arrival of the boll weevil, an insect that feeds on cotton buds and flowers, caused widespread devastation to cotton crops, thereby reducing the demand for child labor in cotton harvesting.

Despite its negative impacts on agricultural output, income, land value, and parental employment opportunities, studies suggest that the staggered arrival of boll weevil resulted in overall improvements in children's educational outcomes. Baker (2015) employs county-level data from Georgia between 1914 and 1929 and uses the appearance of the boll weevil as an instrument for cotton production. He documents that a 10% decline in cotton production results in a 2% increase in the school enrollment rate among black children with no discernible impact on white children. Using the universe of southern counties, Baker et al. (2020) use the 1940 census and document that both white and black children who were 4-9 years old at the time of boll weevil's arrival reveal 0.24-0.36 additional years of higher completed education. Clay et al. (2020) document a 6% increase in wage income of black individuals who were exposed to the boll weevil during their childhood as observed in 1940. Lange et al. (2009) find that the boll weevil substantially reduced cotton production and cotton yield. They show that farmers shifted to other crops, although they faced reductions in land values. Further, they document considerable out-migration post-arrival of the pest, especially in counties with a higher baseline cotton production. Bloome et al. (2017) document reductions in the share of married individuals among African Americans following boll weevil's arrival. Among African Americans aged 20-29, the share of married individuals fell by roughly 3.7%.

These changes in social and economic conditions can affect children's outcomes in various ways, making a priori expectations about the net effects on later-life outcomes ambiguous. For example, the increases in schooling and migration likelihood could be at least partly counteracted by the worsening economic circumstances of the children's families and communities due to boll weevil infestations. We employ Social Security Administration male death records linked to the full count 1940 census to examine the effects of early life and childhood exposure to the boll weevil on later-life old-age longevity. Recent developments in cross-census linking algorithms allow us to link individuals from the 1940 census to historical full count censuses 1900-1930 in order to infer county of birth/childhood, an essential identifier in our setting. The data also provides a wide array of family socioeconomic and sociodemographic characteristics, which enables the implementation of heterogeneity analyses. We find net positive effects on the longevity of individuals who were exposed to the infamous agricultural pest during their childhood years. Specifically, full exposure to the boll weevil throughout childhood is associated with an increase in longevity of about 1.1 months. Among African Americans, the effects are roughly 77% larger than whites. We document that the impacts are almost exclusively concentrated among low educated families and in counties with higher cotton production levels in 1900. Moreover, we find aspects of dynamic substitutability with state-level child labor laws whereby we observe considerably larger effects in states that have more liberal regulations regarding child labor and a small and insignificant effect in states with more restrictive child labor policies. In other words, negative labor demand shocks a child-labor-intensive industry manipulate incentives similar to child labor policies.

Further, we implement a wide array of sensitivity checks and document that the observed impacts are quite robust to alternative specifications, functional forms, and sample selections. A

series of event studies rule out concerns regarding pre-existing trends in education and longevity outcomes. We also show that endogenous changes in the sociodemographic and socioeconomic composition of the individuals in the final sample are not likely to confound the estimated effects. We further provide arguments that the limited death window selection likely underestimates the results and that the true effects are likely larger.

Consistent with prior literature, we observe that exposed individuals are more likely to migrate out of their county and state of birth/childhood in 1940. They are more likely to move from rural areas to urban areas, and the average socioeconomic index of their county of residence in 1940 is higher. We find larger coefficients among the subsample of migrants, an increase of 4.6 months in longevity, which suggests that migration provided benefits and might be a pathway for the observed long-term links.

Reductions in the marginal productivity of child labor might discourage parents from having additional children by increasing the shadow price of children (Becker, 1960; Becker & Lewis, 1973). The resulting decreases in quantity of children may increase per child resources and investments, with implications for their health outcomes later in life (Hanushek, 1992). Using historical censuses 1900 – 1930, we observe significant reductions in fertility rates. Interestingly, similar to the effects on longevity, we observe larger reductions among black families. Fathers in these families are more likely to change occupation away from farming and toward manufacturing, services, and other sectors. However, we do not observe an overall change in their occupational scores or measures of socioeconomic status.

To further examine the mechanisms, we use the 1940 census and assess the effects of exposure on measures of education and socioeconomic status, given the literature that documents a link between education, income, socioeconomic status, and longevity (Fletcher, 2015b; Galama

et al., 2018; Lleras-Muney et al., 2022). Full exposure to the boll weevil during childhood is associated with 0.11 additional years of higher education, 7.9% higher college attendance, and about 1.5% increase in their socioeconomic index.

This study makes three important contributions to the literature. First, it adds to the small literature that evaluates the impacts of the boll weevil on children's later-life outcomes (Baker, 2015; Baker et al., 2020; Bloome et al., 2017; Lange et al., 2009). Although the boll weevil was eradicated in the 1970s, many developing countries still face similar invasive pests, plant pathogen epidemics, and other viral diseases. For instance, many countries in recent decades experienced agricultural pest crises, including the infamous cotton pests in West Africa, coffee leaf rust in Central America, Maize Lethal Necrosis Disease (MLND) in East Africa, and many instances of locust outbreaks in Africa and Asia. Besides, there is evidence that climate change significantly contributes to the spread of agricultural pests, especially in temperate zones (Schneider et al., 2022). Since policy interventions are costly, it is important to have a full picture of their impacts and the relevant pathways and settings.

Second, since the findings point to a substitution of schooling for child labor as an important pathway, this paper also adds to the literature that examines the effects of education on mortality.⁴ The reduction in the marginal productivity of child labor was plausibly exogenous as it was tied to the spreading path of the boll weevil. The presence, pace of population growth, and expansionary path of the pest was difficult to anticipate as it depended on several unpredictable

⁴ We should note that the literature on the education-health gradient in general, and education-mortality specifically, is far from conclusive and provides mixed evidence depending on the cohort, setting, method, and data (Albarrán et al., 2020; Albouy & Lequien, 2009; Black, Hsu, et al., 2015; Brunello et al., 2016; Buckles et al., 2016; Clark & Royer, 2013; D. M. Cutler & Lleras-Muney, 2006; Fischer et al., 2013; Fletcher et al., 2021; Fletcher, 2015a; Fletcher & Frisvold, 2011; J. Fletcher & Noghanibehambari, 2023; Lager & Torssander, 2012; Leuven et al., 2016; Lleras-Muney, 2005; Lleras-Muney et al., 2022; Mazzonna, 2014; Meghir et al., 2018; Noghanibehambari & Fletcher, 2023a; Spoerri et al., 2014). Several studies review this literature, including Hamad et al. (2018), Xue et al. (2021), and Galama et al. (2018).

factors, including wind direction, humidity, temperature, trade routes for agricultural equipment and other inputs, biological resistance of each generation to certain local control measures, and other environmental barriers such as mountains, lakes, rivers, and dry regions (Fye, 1968; McKibben et al., 1991; Pierce, 1912). The unpredictable spatial and timing movements of the boll weevil add to the exogeneity of the shock, hence arguably unconfounded long-term links.

Third, we contribute to the growing literature that examines the impacts of early life and childhood exposures and later-life mortality.⁵ We provide evidence that reducing child labor and increasing schooling outcomes in the early years of childhood could outweigh the potentially negative effects of adverse economic shocks. This fact carries important policy implications, especially for developing countries with weak prevailing policies regarding child labor and education (Chorny et al., 2019).

The rest of the paper is organized as follows. Section 2 reviews the historical background. Section 3 introduces data sources and the process of sample selection. Section 4 discusses the econometric method. Section 5 reviews the results. Section 6 explores mechanism channels. Section 7 concludes the paper.

2. Historical Background

The boll weevil (scientific name: *Anthonomus grandis*) is a small beetle with a keen appetite for cotton buds and flowers. It is native to Central America and Mexico. In the late 19th century, it gradually spread northwards due to the expansion of cotton cultivation, migration, trade

⁵ This literature examines a wide array of early life shocks, including family socioeconomic status, family structure, local economic shocks, social policies and cash transfers, natural disasters, pesticide exposures, and several county level, state-level, and federal policy reforms (Case & Paxson, 2009; Finch & Crimmins, 2004; J. Fletcher & Noghanibehambari, 2024; Hayward et al., 2013; Hayward & Gorman, 2004; Lindeboom et al., 2010; Montez & Hayward, 2011; Noghanibehambari et al., 2024; Noghanibehambari & Engelman, 2022; Noghanibehambari & Fletcher, 2023c, 2023d, 2023f, 2023a, 2023b; Noghanibehambari & Noghani, 2023; Schmitz & Duque, 2022; Scholte et al., 2015; Smith et al., 2006; Van Den Berg et al., 2006).

routes, and the movement of goods and agricultural products between Mexico and the US. It was first detected in the US in 1892 near Brownsville, Texas. After its arrival in Texas, the boll weevil expanded rapidly across the Southern United States, primarily because of its ability to fly short distances and its hitchhiking on cotton shipments. By 1903, it had spread to Louisiana, and within the next two decades, it reached most of the Cotton Belt, including Mississippi, Alabama, Georgia, and the Carolinas. By the 1920s, the boll weevil had infested the entire Cotton Belt, causing widespread destruction. The top panel of Figure 1 depicts the year of boll weevil's arrival across counties in the Cotton Belt.⁶

The boll weevil lays its eggs inside cotton buds and bolls (the rounded seed capsules of the cotton plant). The larvae feed on cotton bolls, resulting in the destruction of the plant. Many of the control measures, such as crop rotation, destruction of cotton stalks after harvest to reduce overwintering sites, and the development of early-maturing cotton varieties, produced limited impacts. Overall, the boll weevil's invasion significantly reduced cotton yields in cotton production counties and adversely affected local economies in the Cotton Belt. Lange et al. (2009) document that cotton production dropped by roughly 50% within five years of the boll weevil's arrival in a county.

Cotton was the staple crop of the US South. Roughly 75% of the total raw cotton production of the world came from Cotton Belt counties in the US during the early decades of the 20th century (Jordan, 1910). The mechanization of cotton production advanced in the years after World War II (Fite, 1950). Therefore, in prior decades, cotton bolls were picked by hand. The physical characteristics of the children made them suitable candidates for cotton harvesting during the

⁶ Cotton Belt states in the final sample include Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia.

harvest season, which lasted from September through December. Since many families were tenant farmers, it was common to use children as substitutes for adult labor. Early surveys from this period suggest that 66% of white children and 76% of black children engaged in farm work during the harvest season, nearly all of whom were involved in picking cotton (Bradley & Williamson, 1969). The arrival of the boll weevil disrupted this long-standing equilibrium by reducing the marginal productivity of child labor.

3. Data Sources

The primary source of data for this study comes from Social Security Administration Death Master Files (henceforth DMF) provided by the Censoc project (Goldstein et al., 2021). The data reports deaths that occurred among men between the years 1975-2005. There are three advantages to using the DMF data in our setting. First, the data can be linked to the 1940 census at the individual level. The linkage allows us to observe all individual and family level characteristics as reported in the 1940 census, including several measures of socioeconomic status, education, family structure, and granular residential location. Second, the initial data contains roughly 8 million death records. After the sample selection procedures explained below, focusing on affected cohorts in affected locations, we are still left with a relatively large sample size. This is in sharp contrast with alternative data sources that can be linked to the 1940 census, such as the Health and Retirement Study, which produces considerably smaller sample sizes on the order of several thousand. Third, since a large portion of individuals in the 1940 census can be linked back to historical censuses from 1900 to 1930, we can extract their county of residence during early life and childhood. This sub-state location identifier for place of birth, early life, and childhood allows us to examine granular shocks on long-term outcomes. It is arguably a rare piece of information in primary datasets that also report mortality and longevity.

The procedure of inference of the early life county of residence is as follows. First, a subset of the DMF data is also recorded in the Numerical Identification death records (henceforth Numident) data. The Numident data covers a considerably shorter death window (i.e., 1988-2005). However, it reports the county of birth as reported in individuals' Social Security records. We use county of birth in the Numident data for those observations in the DMF data that are also recorded in the Numident. Roughly 49% of observations are assigned county of birth using this method. Second, we employ cross-census linking rules provided by Price et al. (2021) to link 1940 records to full count historical censuses 1900-1930. Roughly 4.6% of observations are linked to the 1900 census and are assigned county of residence in 1900 as the county of early life and childhood. Similarly, 8.6%, 11.7%, and 13.4% of observations are linked to the 1910, 1920, and 1930 censuses, respectively. We use county of residence in those censuses, in ascending order, as the county of birth, early life, and childhood. The 1940 census asks about the county of residence five years ago, i.e., 1935. If the individuals have migrated during the past five years, we use the county of residence in 1935 as the early life county. That accounts for 1.5% of observations. Finally, for all unlinked observations, we use the county of residence in 1940 as a proxy for the early life county. About 10.5% of observations are assigned the 1940 county as the early life county.⁷

In the same manner that we extract early life county from historical censuses, we extract maternal literacy and paternal socioeconomic status. In addition, we restrict the sample to birth cohorts of 1890-1940, to cover several cohorts before and after the boll weevil expansions. We further restrict the sample to individuals who were born five years after the arrival of the boll weevil and who are at most 25 years old at the time the boll weevil arrived in the county. To

⁷ In Appendix A, we compare statistics of the final sample with those of the original population observed in the 1940 census. Further, we show that there is no discernible and sizable correlation between the exposure measure and successful data merging, suggesting that the process of data linking is not likely to confound our estimates.

account for time-varying county characteristics, we construct a county-by-year panel based on information in historical censuses 1880-1940 and interpolate linearly for inter-decennial years. We merge this panel with our DMF data based on early life county and birth year.⁸

The data on the year of boll weevil’s arrival is extracted from Baker et al. (2020). The data on agricultural production is taken from Gutmann (2005). All census data are extracted from Ruggles et al. (2020).

Summary statistics of the final sample are reported in Table 1. The final sample covers 734,374 observations. We split the sample into cohorts based on their exposure to the boll weevil in their county of birth-early life. The exposed group consists of those with a full exposure to the boll weevil during their childhood (i.e., ages 4-17), and the non-exposed group contains individuals with no/partial exposure during their childhood years. Although it seems an arbitrary split, the event studies disentangle the impacts across different ages at exposure (discussed in section 5.1).

Exposed individuals live on average 897.4 (74.8) months (years), while non-exposed individuals reveal a lifespan of 972.3 (81) months (years). Figure 2 illustrates the density distribution of age-at-death for the full sample.

Roughly 78% of observations in both exposed and non-exposed groups are whites. Exposed individuals consist of more later birth cohorts (on average, 1916), and non-exposed individuals comprise earlier cohorts (on average, 1905). The fact that control cohorts have, on average, higher longevity than exposed cohorts partly mitigates the concern that the limited death window (i.e., 1975-2005) adds selection bias to our estimates. If the impacts are confounded by death window selection, then we would observe higher longevity for earlier cohorts who were

⁸ The main results of the paper are based on a sample of counties that ever experienced the boll weevil as reported by Baker et al. (2020). In Appendix C, we include all US counties and replicate the main results. We observe comparable and, in the fully parameterized model, slightly larger coefficient sizes.

selected from comparably lower life expectancy cohorts and later cohorts. The positive impacts on longevity of later cohorts (with lower average longevity in the selected window) in comparison with earlier cohorts (with higher average longevity in the selected window) operate in the opposite direction as one would expect from selections due to limited death window.

For the analysis regarding the mechanism channel, we restrict the sample to individuals above age 17 and focus on outcomes in the 1940 census. On average, individuals attain 8.4 and 8 years of schooling in exposed and unexposed groups, respectively.

4. Econometric Method

Our empirical method relies on the plausibly exogenous staggered spread of the boll weevil. The arrival of the boll weevil was likely exogenous, as it was connected to the boll weevil's unpredictable spatial and temporal diffusion. The pest's presence, population growth rate, and expansion path were challenging to forecast, influenced by various unpredictable factors, including wind patterns, humidity, temperature, agricultural trade routes, the biological resistance of each generation to local control efforts, and environmental obstacles like mountains, lakes, rivers, and arid areas. Therefore, it is unlikely that county-level arrival of the boll weevil correlates with determinants of local population health and longevity.

We implement difference-in-difference event study regressions to compare the longevity of individuals who were exposed to the boll weevil across different ages. We assume that the longevity of individuals across different ages at the time of the boll weevil's arrival would have followed the same evolutionary path in the absence of the arrival of the boll weevil. Specifically, we employ the following regressions:

$$y_{icb} = \alpha + \sum_{j \neq 13} \beta_j I(T_c^* - b = j) + \gamma X_{icb} + \lambda Z_{cb} + \xi_c + \zeta_b + \varepsilon_{icb} \quad (1)$$

The outcome, y , is age at death (measured in months) of individual i born in county c and year b . $I(.)$ equals one if the inside argument is true and zero otherwise. The parameter T^* represents county-specific year of boll weevil's arrival. Therefore, coefficients β represent longevity differences of cohorts at different ages at the time of boll weevil's arrival. We use the arbitrary age of 13 as the contrast group. In matrix X , we include race and ethnicity dummies as individual covariates and paternal socioeconomic status and maternal education dummies as parental covariates. In matrix Z , we include county by cohort covariates, including per capita homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in different industries, and share of married individuals. County fixed effects, represented by ξ , account for all unobserved characteristics of counties that affect children's outcomes and are common across birth cohorts. The parameter ζ represents birth year fixed effects, which absorb unobserved determinants of longevity that vary over time but are common across different counties. Finally, ε is a disturbance term. Standard errors are clustered at the county level to account for serial correlations in error terms.

To summarize the event study coefficients of equation 1, we construct an exposure variable that indicates a full exposure the boll weevil during ages 4-17. We then use this variable as the primary independent variable in regressions similar to equation 1, as follows:

$$y_{icb} = \alpha + \beta \text{ExpShare}_{cb} + \gamma X_{icb} + \lambda Z_{cb} + \xi_c + \zeta_b + \varepsilon_{icb} \quad (2)$$

All parameters are similar to those of Equation 1.

5. Results

5.1. Event Study Results

The main results of Equation 1 are depicted in the top panel of Figure 3. The coefficients associated with exposure to the first year of the arrival of the boll weevil across ages post-13 are small and insignificant. Specifically, the coefficient that represents exposure at age 14-and-above reveals an economically and statistically zero effect. However, for those aged 6-12 at the time of the boll weevil's arrival, we observe relatively larger and, in some cases, statistically significant coefficients. The distinct rise in coefficients occur for children at age 5-and-under. Specifically, the coefficients reach maximum levels and stabilize in magnitude around age at exposure of 2-and-below.

Suppose the effects, as we discuss in section 6, are partly driven by school attendance and educational outcomes. In that case, it may seem counterintuitive that we do not observe larger impacts among other childhood years, specifically ages 13-17, as represented by event time dummies in this figure. We should note two facts to gain a better understanding of the overall pattern of the coefficients. First, the impacts on school enrollment and completed education were also substantially higher among younger children, especially ages 4-6 (Baker et al., 2020). Indeed, the event studies of educational outcomes, reported in section 6.4, produce a quite similar pattern as those of longevity. Second, the largest impacts of the boll weevil did not materialize in the first period that they were detected in a county. Maturation, proliferation, and establishment of the boll weevil in a cotton farm took more than a year (Lange et al., 2009). The spatial spread of the boll weevil across all farmlands in the county was also not a one-year phenomenon and took several periods. Therefore, it is possible that the impacts are concentrated among younger children. However, it is also possible that there is a lag in the impacts, and the increase in the coefficients around age 5 may partly reflect these lags rather than indicating a specific critical age.

In the bottom panel of Figure 3, we show that the results are quite robust when accounting for treatment heterogeneity using the method developed by Sun & Abraham (2021). In Appendix Figure D-1, we employ the method developed by De Chaisemartin & D’haultfoeuille (2020) that employs only not-yet treated groups for comparisons of two-way fixed effects. We observe comparable patterns and coefficient magnitudes across panels.

5.2. Difference-in-Difference Results

The main results of Equation 2 are reported in Table 2. We start with a parsimonious specification in column 1 and add more covariates across consecutive columns. The coefficients are fairly robust. The fully parameterized regression of column 3 suggests that full exposure during childhood to the boll weevil is associated with about 1.1 months increases in longevity.

We can understand the economic significance of this effect by looking at other long-term determinants of longevity. For instance, Noghanibehambari & Fletcher (2023e) examine the long-lasting legacies of early-life exposure to the Dust Bowl of the 1930s for later-life mortality. They find that the longevity of male individuals from farmer families who were exposed to topsoil erosions due to the Dust Bowl drops by about 2.5 months. Therefore, the benefits of reductions in child labor due to the boll weevil are roughly 45% of the adverse impacts of substantial drops in agricultural income as a result of the Dust Bowl. Aizer et al. (2016) examine the impacts of the Mother Pension (MP) program under which poor single-mother families received cash transfers for up to three years in the early 20th century. These transfers accounted for about 40% of pre-transfer family income. They document that the MP is associated with roughly 12-month increases in longevity of male children. Therefore, the intent-to-treat the effects of the arrival of the boll weevil is about 10% of treatment-on-treated effects of a relatively generous and long-lived social program. Chetty et al. (2016) use tax return data linked to death records and examine the

relationship between income and longevity. They document that each additional income percentile is associated with roughly 1.4 months higher longevity. Therefore, the longevity effect of the boll weevil is equivalent to a rise in income distribution of about 0.8 percentiles. This is roughly a \$6,400 change from the mean of income (in 2020 dollars).

5.3. Heterogeneity Analyses

Black children were more likely to work as child laborers in cotton cultivation forms than their white counterparts. Baker (2015) and Baker et al. (2020) find considerably larger impacts on school enrollment and completed education among black children compared to white children. Clay et al. (2020) also find larger impacts on the wage income of Blacks than whites for their early life and childhood exposure to the boll weevil. Therefore, one would expect to observe a similar pattern for longevity. In columns 1-2 of Table 3, we examine the impacts in the subsample of whites and Blacks, respectively. We observe a considerably larger coefficient among Blacks, suggesting increases in longevity of about 1.7 months, 77% larger than the effects on whites in column 1.

In columns 3-4, we examine heterogeneity based on maternal literacy. we observe a larger effect for children of illiterate mothers compared with literate mothers (2.4 versus 0.8 months), consistent with studies documenting heterogenous impacts of early life exposures by maternal education (Fletcher & Noghanibehambari, 2024; Rauscher & Cao, 2024) (columns 3-4). families of low educated parents are more likely to be farm laborers, and it is not uncommon for them to employ children as extra hands during the harvest seasons. Moreover, these low educated parents are also less likely to invest in the human capital of their children, hence more likely to encourage child labor (Emerson & Souza, 2003; Mukherjee & Das, 2008). Therefore, it is not surprising that the impacts are exclusively concentrated among families with low education.

Additionally, we observe substantially larger impacts in counties that have above-median share of farmers (columns 5-6). We also find heterogeneity based on the intensity of cotton production in the year 1900. The effects become larger for the subsample of the top quartile of 1900 cotton production and become smaller and statistically insignificant for the subsample of the bottom-three quartiles of 1900 cotton production (columns 7-8).

Children of farmers may be considered productive assets, as they can help parents reduce production and harvesting costs or increase efficiency. Studies suggest that reductions in the value and productivity of child labor in agricultural production post-World War II were associated with decreases in foreign-born fertility rates (Rosenzweig, 1977). Therefore, one would expect differential impacts based on parents' farm-related occupational status. Indeed, we observe significantly larger impacts among children whose fathers' occupations are farm-related. The coefficient suggests an increase of 2.4 months in their longevity, although estimated noisily.

Early life Exposures and policies may interact to influence long-term outcomes (Conti et al., 2016; Cunha & Heckman, 2007; Johnson & Jackson, 2019). In our setting, an important factor that could dynamically interact with the aftermath of the boll weevil is the presence and stringency of child labor policies. We use data from Acemoglu & Angrist (2000) and assign different measures of child labor to individuals based on their state of birth. We then split the sample based on stringency and rigidity of child labor policies and replicate the results in columns 1-2 of Table 4. We observe an increase in longevity of about 1.4 months for full exposure of children to the boll weevil in states with liberal or no child labor policies. For states with more restrictive child labor laws, we observe an effect size of 0.3 months, although statistically insignificant. These results suggest that there is a degree of substitutability between child labor policies and changes in marginal productivity of child labor as a result of the arrival of the boll weevil.

5.4. Sensitivity Analyses

In Table 5, we investigate robustness checks to alternative specifications. To have a benchmark comparison, we replicate the results of column 3 of Table 2 in column 1 of this table. In column 2, we allow for the influence of time-invariant county characteristics to have a differential impact on longevity based on individual race, maternal literacy, and paternal socioeconomic status. The estimated coefficient is comparable to that of column 1. To account for cross-cohort differential evolution of longevity across different census divisions, we interact census-division-of-birth by birth-year fixed effects in column 3. The estimated effect is slightly smaller than the main results but remains economically and statistically meaningful.

To account for cross-state migration and specifically the influence of the great migration of Southerners to Northern states, we add the interaction of birth state fixed effects by state of residence in 1940 fixed effects. The results, reported in column 4, are almost identical to that of column 1.

A small strand of research documents the influence of the season of birth on later-life longevity (Vaiserman, 2021; Vaiserman et al., 2002). In addition, there is a narrow literature that documents the phenomenon of seasonality in mortality outcomes (Falagas et al., 2009; Seretakis et al., 1997). To address such seasonality concerns, we add birth month and death month fixed effects into our regressions. The results, reported in column 5, reveal a comparable coefficient to that of column 1.

In columns 6-9, we examine the robustness to alternative functional forms. In column 6, we replace the outcome with the log age-at-death. Full exposure is associated with 0.12% rise in longevity, which is similar to the implied percentage change with respect to the mean of the outcome in column 1. In columns 7-9, we examine the effects on longevity beyond ages 70, 75,

and 80, respectively. Full exposure is associated with 46, 63, and 49 basis points increases in the probability of longevity beyond age 70, 75, and 80, respectively. Comparing with the mean of the outcomes, these effects can be translated into a change of 0.6%, 1%, and 1.2%, respectively.

In column 10, we weight regressions by the share of farmers in 1900 to assign higher weights to counties with a higher share of farmlands. Although the estimated coefficient drops slightly, it remains comparable to that of column 1.

A research strand examines the influence of exposure to the 1918 influenza and later-life outcomes, including mortality and longevity (Almond, 2006; Fletcher, 2018a, 2018b, 2018c; Myrskylä et al., 2013; Noghanibehambari & Fletcher, 2023e). To mitigate the 1918 influenza's confounding influence on our results, we remove cohorts born between 1918 and 1919 and replicate the results. The estimated coefficient, reported in column 11, is larger than column 1.

During the same period in the southern counties, there were two prominent public health interventions to eradicate hookworm (during 1910s) and malaria (during 1920s) diseases. Studies suggest that these eradication campaigns are associated with improvements in later life human capital and measures of socioeconomic status (Bleakley, 2007, 2010; Bleakley & Lange, 2009; Elman et al., 2019; Henderson, 2018). To control for the potential confounding influence of these eradication campaigns, we extract county level hookworm treatment data from Henderson (2018) and state-level malaria risk index data from Bleakley (2010). We then interact these measures with birth year fixed effects to flexibly allow these exposures to vary across cohorts and include them in the regressions. Although the point estimate drops slightly, it remains comparable to that of column 1.

Another concern is that the boll weevil affected counties/cohorts that were inherently different than unaffected groups. Similarly, post-boll weevil, out-migration could occur among

certain subpopulations more than others, and the characteristics of migrants/stayers correlate with their health and longevity. We empirically address both of these concerns using balancing tests by regressing observable characteristics of individuals in the final sample on exposure measure, conditional on county and cohort fixed effects. These results are reported in Table 6. We find insignificant changes in the share of whites and Blacks (columns 1-2). The respective changes implied by these coefficients are also very small. For instance, the coefficient of white in column 1 implies a change of 0.7% with respect to the mean of the outcome. We observe increases in the socioeconomic index of fathers (column 3, implied change of 0.6%). Moreover, we observe a small and statistically insignificant change in the share of individuals with literate mothers (column 5, implied change of 0.04%).

Overall, the estimations of this table are not concerning for two main reasons. First, the implied percentage changes with respect to the mean of the outcome are quite small in magnitude. Second, if anything, they add a downward bias into our regressions as children of low socioeconomic status families have lower later-life longevity. Therefore, the overall positive effects provide a lower bound of the true effects.

To complement the analysis of this section, we also implement similar balancing tests using the original population of these cohorts in the 1940 census prior to merging with the DMF data. These results, reported and discussed in Appendix C, provide a similar story and do not support concerns regarding endogenous compositional changes.

6. Mediatory Outcomes

6.1. Agricultural Production

In Appendix B, we investigate the effects on several agricultural production outcomes using data for a subset of counties. In so doing, we employ data from Gutmann (2005) that reports

production data for decennial years and merge with the boll weevil’s arrival date database. We investigate the associations between production and a dummy variable indicating post-boll weevil year, conditional on year and county fixed effects. We observe a decrease of roughly 55% in cotton production post-arrival of the boll weevil. This is quite comparable to the estimates of Lange et al. (2009). Further, we do not find significant changes in the production of other crops, including barley, rye, or other legume production.

6.2. County-level socioeconomic and sociodemographic outcomes

The arrival of the boll weevil can change the landscape of affected counties in many ways, including compositional changes in sociodemographic characteristics or compositional changes in occupations and measures of occupational standing. We use decennial censuses between the years 1880-1940 to construct a county-by-year panel and examine the evolution of county-level characteristics using event studies of the following form:

$$y_{ct} = \alpha + \sum_{i \neq -1} \beta_i I(t - T_c^* = i) + \xi_c + \zeta_t + \varepsilon_{ct} \quad (3)$$

The parameters ξ and ζ represent county and year fixed effects. The parameters β_i ($i < -1$) and β_i ($i > 0$) represent the difference between the outcome in years before and after the boll weevil’s arrival year (T^*) relative to the outcome in one year prior to the arrival (i.e., $i = -1$). To ease the interpretation, we standardize outcomes with respect to the mean and standard deviation of the full sample.

The estimates of equation 3 are reported in different panels of Figure 5 through Figure 7. We observe a discernible drop in the share of individuals working on farms but increases in other blue-collar occupations and all other occupations. However, there is no overall impact on occupational income score (Figure 5).

We observe large and significant reductions in the share of married individuals, consistent with the findings of Bloome et al. (2017). Additionally, we observe reductions in the number of children under five years old, implying decreases in fertility (top right panel of Figure 6). Despite these changes, we do not observe discernible changes in the share of whites or Blacks (bottom panels of Figure 6). We also do not observe significant changes in the average socioeconomic index, the share of literate people, the share of homeowners, or population (Figure 7).

Although these results point to sharp drops in employment in the farming sector, the substitution of other occupations and other sectors appears to offset the overall negative impacts. This can partly explain why we do not observe significant changes in occupational income scores and socioeconomic index. Therefore, these substitutions limit the overall negative impacts of worsening local economic conditions on later-life outcomes. Further, even though we observe reductions in marriage and fertility, the fact that there are virtually no changes in the demographic composition of counties rules out the concern regarding the overrepresentation of certain demographic groups with differential longevity as the confounding influence in our estimates.

6.3. Migration

Prior research suggests in-migration to cotton production counties in years prior to the boll weevil and out-migration in years after the arrival of the boll weevil (Lange et al., 2009). By comparing county and state of birth with county and state of residence in 1940, we can construct measures of cross state and cross county migration and examine the role of migration in our analysis. These results are reported in Table 7.

First, we examine cross state migrations. We observe significant increases in the probability of moving to Northern states (Midwest or Northeast). The effect implies a change of 3.2% (column 1). However, the implied effect of moving to another southern state is slightly larger,

4.5% (column 2). We do not observe a discernible change in South – West migration (column 3). Additionally, we observe increases in cross county migration by about 0.8% with respect to the mean (column 4).

Migration exposes individuals to different landscapes with potential later-life benefits (Finkelstein et al., 2021) or adverse impacts (Aaronson et al., 2021). We use the average socioeconomic index in the destination county (i.e., 1940 county of residence) as a measure of place attainment and destination location place quality. We find increases in rural to urban migration (column 5) and to counties with higher socioeconomic index (column 6). Therefore, one possible mechanism is the exposure to better neighborhoods due to migration induced by the boll weevil. When we examine heterogeneity by migrant status, we find that the effects are exclusively concentrated in the subsample of migrants, suggesting an increase in longevity of about 2.5 months. The benefits of better neighborhoods can operate through a number of channels with potential impacts on later-life outcomes (including mortality), such as better access to healthcare, higher schooling quality, lower crime, and lower pollution (Finkelstein et al., 2021).

6.4. Education and Socioeconomic Status

Several studies provide evidence that better-educated individuals and those with higher measures of socioeconomic status are healthier and live longer lives (Chetty et al., 2016; Fletcher et al., 2021; Galama et al., 2018; Lleras-Muney, 2005). Since reductions in the availability of child-labor-intensive cotton cultivation lower the opportunity cost of schooling and incentivize school attendance, affected children might attain higher education and socioeconomic status levels later in life (Baker et al., 2020). To investigate these mechanism channels, we limit the sample to individuals above age 18 and explore the effects of exposure on outcomes in the 1940 census.

These results are reported in Table 8. We observe an increase of roughly 0.11 years in schooling (column 1). Moreover, we observe a reduction of 0.7 and 0.8 percentage points in the probability of education less than high school and education less than 12 years, respectively (columns 2-3). We further find an increase of 0.7 percentage points in the probability of any college education, equivalent to a change of 7.9% comparing with the mean of the outcome (column 4). Finally, we observe an increase of about 0.4 units in the socioeconomic index, off a mean of 24.1 (column 5).

In Figure 4, we examine the overall pattern and evolution of coefficients across different cohorts using event studies of equation 1 for several measures of education. There are two facts worth mentioning here. First, we do not observe discernible pre-existing trends in educational outcomes. Second, the overall patterns are quite similar to those of Figure 3, specifically that there is a possible lag in the effects that appear for these outcomes.

Lleras-Muney et al. (2022) use a sibling fixed effect strategy and examine the effects of education on longevity. They find that each additional year of schooling is associated with approximately 5 months higher longevity. Using their results and the estimated coefficient of column 1 of Table 8, we can calculate an increase of 0.55 months in longevity as a result of improvements in education. This is about 50% of the reduced form effect we observe in Table 2. Fletcher & NoghaniBehambari (2023) examine the effects of college openings on college education and later-life longevity. They estimate that any college education is associated with about 15.6 months higher longevity. Combining their estimates and the coefficient of column 4 of Table 8, we can calculate an increase of about 1.2 months in longevity as a result of increases in college education due to early life exposure to the boll weevil. This can fully explain the reduced

form effects documented in Table 2. Therefore, we conclude that improvements in educational outcomes drive a large portion of the observed effects.

6.5. Parental Fertility Decisions

Decreases in the marginal productivity of child labor could discourage parents from having more children by raising their shadow price (Becker, 1960; Becker & Lewis, 1973; Frenette, 2011). This decline in the number of children may lead to increased resources and investments per child, potentially improving their health outcomes later in life (Bleakley & Lange, 2009; Hanushek, 1992). To examine changes in fertility due to the arrival of the boll weevil, we construct a longitudinal data by linking individuals in historical censuses 1900 – 1930. In so doing, we link individuals from 1900 to 1910 – 1930 and exclude unlinked individuals. We also link individuals from 1910 to 1920 – 1930 and restrict the sample to link individuals only. We then pool these linked data. We further restrict the sample to male individuals aged 20 – 55. We implement regressions of the following form:

$$y_{icy} = \beta BWPost_{ict} + \gamma_i + \theta_c + \eta_t + \varepsilon_{ict} \quad (4)$$

Where $BWPost$ is a dummy indicating that boll weevil has arrived in county c in decennial census t . Individual, county, and decennial census year fixed effects are represented by γ , θ , and η , respectively. Standard errors are clustered on county.

The results are reported in Table 9. We observe a reduction in the number of under-5 children in the family post-boll weevil. The estimated coefficient implies a change of 1.3% with respect to the mean. We find larger reductions among black individuals than white individuals (columns 2-3). Additionally, we observe larger reductions among individuals in non-farming sectors, consistent with the fact that post-boll weevil arrival individuals are more likely to change

occupations (reported in columns 8-11). The estimates are robust when we use dummy variables indicating the number of under-5 children more than two and three, equivalent to decreases of roughly 3.5% and 7.3% from the mean of these outcomes (columns 6-7).

In columns 8-11, we find that exposed individuals are less likely to be employed in the farming sector and more likely to work in manufacturing, service, and other industries. However, as reported in columns 12 – 13, there is no change in occupational income score and socioeconomic index of affected individuals. We also do not observe discernible change in their literacy (column 14).

7. Conclusion

In the early 20th century in the US South, between 30-50% of school-aged children were employed in agriculture and other industries (Walters & Briggs, 1993). Despite significant reductions in child labor and increases in education due to policy changes, growing social awareness, and higher returns to education, the enduring impacts of child labor and education remain important topics for policy analysis. Moreover, many countries today experience similar social and economic developmental stages as the early 20th century US. For instance, among poor and middle-income countries, between 5-28% of children aged 5-17 are engaged in child labor (UNICEF, 2024). Therefore, it is important for policymakers in developing countries to understand the benefits of reductions in child labor and improvements in their schooling.

In this paper, we exploited sudden and unexpected reductions in labor demand for a child-labor-intensive industry to examine its impacts on later-life mortality. Specifically, we focused on the Cotton Belt counties in the US South. We examined how the arrival of the infamous boll weevil, the destructive pest for cotton cultivation, in a county affected children's later-life outcomes. We found a large decrease in cotton production and agricultural employment in the

county following the arrival of the boll weevil. Further, exposed children revealed considerable improvements in education and socioeconomic status during midlife, as observed in the 1940 census. The exposed children are also more likely to migrate out of their county of birth and to counties with a higher socioeconomic index. Employing Social Security Administration death records linked with the 1940 census, we found improvements in the longevity of men. Full exposure to the boll weevil during childhood is associated with about 1.1 months higher longevity. This effect is larger among Blacks and concentrated among children of low educated families residing in counties with high cotton production intensity. Moreover, the effects appear to be substantially larger among children in states with less restrictive child labor policies, implying the role of these policies in reducing the adverse effects of child labor in the absence of the boll weevil in cotton production counties. We showed that the results are quite robust across a wide range of specification checks and alternative functional forms.

Between the years 1890-1940, life expectancy in the US increased from 44.5 to 62.1 years, an increase of roughly 17.6 years (O'Neill, 2023). The intent-to-treat impacts of the boll weevil is equivalent to about 0.5% of the overall improvements in longevity across these cohorts. This overall improvement in life expectancy is largely driven by reductions in infant mortality and child mortality rates during the early decades of the 20th century (Cutler et al., 2006). Based on Social Security Administration period life tables, remaining life expectancy at age 55 increased from 17.24 to 18.04 years from 1900 to 1940. Therefore, the estimated effects of exposure to the boll weevil can explain roughly 11.5% of the overall improvements in life expectancy conditional on age 55 across cohorts of 1900 – 1940.

In the original 1940 census population, about 12.4 million individuals lived in Cotton Belt counties who belonged to birth cohorts 1890-1940 (Appendix Table A-1). The average exposure

variable among these cohorts is 34.3%, implying that about 4.25 million individuals experience a full exposure to the boll weevil. Using the estimates of Table 2, we can calculate roughly 4.67 million life-years gained due to exposure to the boll weevil, reductions in child labor, and improvements in schooling outcomes. One way to understand the magnitude of this gain is to use the Value of Statistical Life (VSL) tables. Studies estimate a VSL of about \$10 million for US residents (Kniesner & Viscusi, 2019; Viscusi, 2018). The average longevity in the final sample is 78.6 years. A simple back-of-an-envelope calculation suggests roughly \$127K for each additional year. Using this estimate and the implied gains in life years due to the exposure to the boll weevil, we calculate a monetary equivalent of the observed longevity improvements across the whole population of roughly \$594.2 billion.

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Tables

Table 1 - Summary Statistics

	Exposed by Age 17		Non-Exposed by Age 17	
	Mean	SD	Mean	SD
Age at death (months)	897.38	110.63	972.26	97.45
Log age at death	6.79	.13	6.87	.1
Age at death > 70	.66	.47	.88	.33
Age at death > 75	.47	.5	.73	.44
Age at death > 80	.27	.44	.52	.5
Birth year	1915.67	6.61	1904.96	7.26
Death year	1990.46	8.44	1986.01	7.76
White	.78	.41	.78	.41
Black	.22	.41	.22	.41
Year of first arrival of boll weevil	1911.61	6.8	1914.06	5.97
Father socioeconomic index	21.22	18.18	20.29	17.49
Father socioeconomic index missing	.18	.38	.2	.4
Mother literate	.75	.43	.74	.44
Mother literacy missing	.18	.38	.17	.37
<i>County covariates:</i>				
Share of homeowners	.43	.12	.42	.14
Number of under-five children	.61	.16	.69	.15
Share of immigrants	.03	.06	.02	.05
Occupational income score	18.18	2.87	17.49	2.54
Per capita literate	.85	.1	.82	.11
Per capita employed	.57	.08	.62	.1
Per capita workers in manufacturing sector	.1	.09	.07	.07
Per capita workers in mining sector	.01	.04	.01	.03
Per capita workers in construction sector	.03	.02	.03	.02
Per capita workers in transportation sector	.05	.04	.04	.04
Per capita farmers	.24	.12	.26	.11
Share of married	.61	.03	.59	.03
Observations	281,516		452,858	
<i>Mechanism sample:</i>				
Years of schooling	8.35	3.62	8.04	3.83
Education less than high school	.51	.5	.58	.49
Education less than 12 years	.75	.44	.76	.43
Any college education	.09	.28	.1	.3
School attendance	.11	.32	.01	.11
Socioeconomic index	21.91	18.76	25.18	21.11
Observations	251,661		452,859	

Notes. The data covers men from birth cohorts of 1890-1940 born in cotton counties and died between 1975-2005.

Table 2 - Exposure to boll weevil During Childhood and Later-Life Old-Age Longevity

	<i>Outcome: Age-at-Death (months)</i>		
	(1)	(2)	(3)
Exposure Share	1.43*** (.39)	1.42*** (.39)	1.13*** (.42)
Observations	734374	734374	734374
R-squared	.32	.32	.32
Mean DV	943.554	943.554	943.554
Birth county FE	✓	✓	✓
Birth year FE	✓	✓	✓
Individual/family controls		✓	✓
Birth county covariates			✓

Notes. Standard errors, clustered on county, are in parentheses. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 3 - Heterogeneity Analysis in the Effects of Childhood Exposure to boll weevil and Later-Life Longevity

	Whites	Blacks	Literate mother	Illiterate mother	Below median share of farmers
	(1)	(2)	(3)	(4)	(5)
Exposure Share	.97** (.46)	1.72* (.9)	.79* (.48)	2.35*** (.79)	.79 (.57)
Observations	572879	159208	544035	190339	367171
R-squared	.31	.36	.32	.35	.32
Mean DV	945.350	937.476	941.457	949.550	950.809
	Above median share of farmers	Top quartile of 1900 cotton production	Bottom-three quartiles of 1900 cotton production	Father occupation farm-labor	Father occupation other
	(7)	(8)	(9)	(10)	(11)
Exposure Share	1.14* (.67)	1.68* (.93)	.15 (.47)	2.36 (1.94)	1.13*** (.43)
Observations	367202	166310	568064	34550	699820
R-squared	.32	.28	.32	.36	.32
Mean DV	936.301	965.471	937.138	927.709	944.336

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 4 - Heterogeneity in the Effects Based on Restrictiveness of State-Level Child Labor Laws

	<i>Outcome: Age-at-Death (months), Subsamples:</i>	
	Less restrictive child labor law	More restrictive child labor laws
	states	states
	(1)	(2)
Exposure Share	1.44*** (.44)	.26 (1.53)
Observations	610904	123470
R-squared	.25	.1
Mean DV	961.340	855.554

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 5 - Robustness Checks to Alternative Specifications

	Column 3 of Table 2	Interacting birth county fixed effects by individual/family dummies	Adding birth region by birth year fixed effects	Adding birth state by 1940 state fixed effects	Adding birth month and death month fixed effects	Outcome: log age at death
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure Share	1.13*** (.4239)	1.1589*** (.4257)	1.0457** (.428)	1.1488*** (.4318)	1.12*** (.4235)	.0012*** (.0005)
Observations	734374	734362	726071	733729	734374	734374
R-squared	.3234	.3259	.3217	.3253	.3241	.325
Mean DV	943.554	943.553	942.822	943.521	943.554	6.843
	Outcome: age at death > 70	Outcome: age at death > 75	Outcome: age at death > 80	Weighted by county share of farmers in 1900	Removing birth cohorts of 1918-1919	Controlling for Hookworm and Malaria Campaigns
	(7)	(8)	(9)	(10)	(11)	(12)
Exposure Share	.0046*** (.0017)	.0063*** (.002)	.0049** (.0021)	.9875** (.4451)	1.3821*** (.4455)	.9844** (.4475)
Observations	734375	734375	734375	722931	692725	639378
R-squared	.192	.2128	.2141	.3272	.3237	.3301
Mean DV	0.795	0.632	0.425	945.014	947.553	944.811

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married. The outcome in columns 1-5 and 10-12 is age at death measured in months.

*** p<0.01, ** p<0.05, * p<0.1

Table 6 - Examining Changes in Sociodemographic and Socioeconomic Composition of the Final Sample Due to Childhood Exposure to boll weevil

	<i>Outcomes:</i>					
	White	Black	Father socioeconomic index	Father socioeconomic index missing	Mother literate	Mother literacy missing
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure Share	.0059*** (.0018)	-.006*** (.0018)	.096 (.0975)	-.0009 (.0026)	-.0003 (.0024)	-.0012 (.0025)
Observations	726072	726072	590743	726072	726072	726072
R-squared	.1631	.1658	.0818	.0499	.0608	.0442
Mean DV	0.778	0.219	20.640	0.186	0.746	0.166

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects and birth year fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Table 7 - Childhood Exposure to boll weevil, Migration, and Later-Life Longevity

	<i>Outcomes and Subsamples:</i>			
	South-North Migrant	South-South Migrant	South-West Migrant	Cross-county migrant from birth to 1940
	(1)	(2)	(3)	(4)
Exposure Share	.0022* (.0012)	.0042*** (.0014)	-.0007 (.001)	.0044* (.0023)
Observations	734375	734375	734375	734375
R-squared	.1135	.0827	.0709	.106
Mean DV	0.069	0.094	0.043	0.521
	Rural-Urban Migrant	Average 1940 County level socioeconomic index	Subsample of migrants Outcome: age-at-death	Subsample of non-migrants Outcome: age-at-death
	(5)	(6)	(7)	(8)
Exposure Share	.0038* (.0022)	.0683*** (.0253)	2.4458*** (.5501)	-.3317 (.6511)
Observations	734375	734349	382966	351408
R-squared	.0813	.3252	.2914	.3386
Mean DV	0.218	25.548	955.640	930.384

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 8 - Exploring Mechanism Channels between Childhood Exposure to boll weevil and Later-Life Longevity

	<i>Outcomes:</i>				
	Years of schooling	Education less than high school	Education less than 12 years	Education college-and-more	Socioeconomic index
	(1)	(2)	(3)	(4)	(5)
Exposure Share	.1045*** (.0173)	-.007*** (.0023)	-.0081*** (.0022)	.0074*** (.0013)	.3718*** (.0897)
Observations	684993	704520	704520	704520	637416
R-squared	.2691	.183	.1387	.0872	.201
Mean DV	8.148	0.554	0.753	0.094	24.098

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 9 - Exploring Mechanism: Parental Changes in Fertility, Occupation, and Socioeconomic Status

	<i>Outcomes:</i>						
	Number of Under-5 Children	Number of Under-5 Children, Whites	Number of Under-5 Children, Blacks	Number of Under-5 Children, Non-Farmers	Number of Under-5 Children, Farmers	Number of Under-5 Children > 2	Number of Under-5 Children > 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exposure Share	-.00619* (.00357)	-.00327 (.00385)	-.01301** (.00536)	-.01663*** (.00529)	.00561 (.00414)	-.00469*** (.00157)	-.00194*** (.00054)
Observations	25709445	19320526	5705726	10897767	11004304	25709445	25709445
R-squared	.39387	.38564	.47001	.42472	.42295	.37996	.35783
Mean DV	0.479	0.477	0.500	0.351	0.629	0.136	0.026
	Occupation: Farming	Occupation: Manufacturing	Occupation: Services	Occupation: Other	Occupational Income Score	Socioeconomic Index	Literate
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Exposure Share	-.01074*** (.00301)	.00583** (.00263)	.00038 (.00043)	.00452* (.0024)	.01568 (.04403)	-.07237 (.07521)	-.00129 (.00194)
Observations	24367809	24367809	24367809	24367809	22313404	22224392	25709445
R-squared	.68072	.52803	.4984	.6234	.70832	.69962	.56307
Mean DV	0.500	0.169	0.024	0.306	19.986	22.431	0.911

Notes. Standard errors, clustered on county, are in parentheses. All regressions include county fixed effects, year fixed effects, and individual fixed effects. The data covers individuals linked in historical censuses 1900-1940.

*** p<0.01, ** p<0.05, * p<0.1

Figures

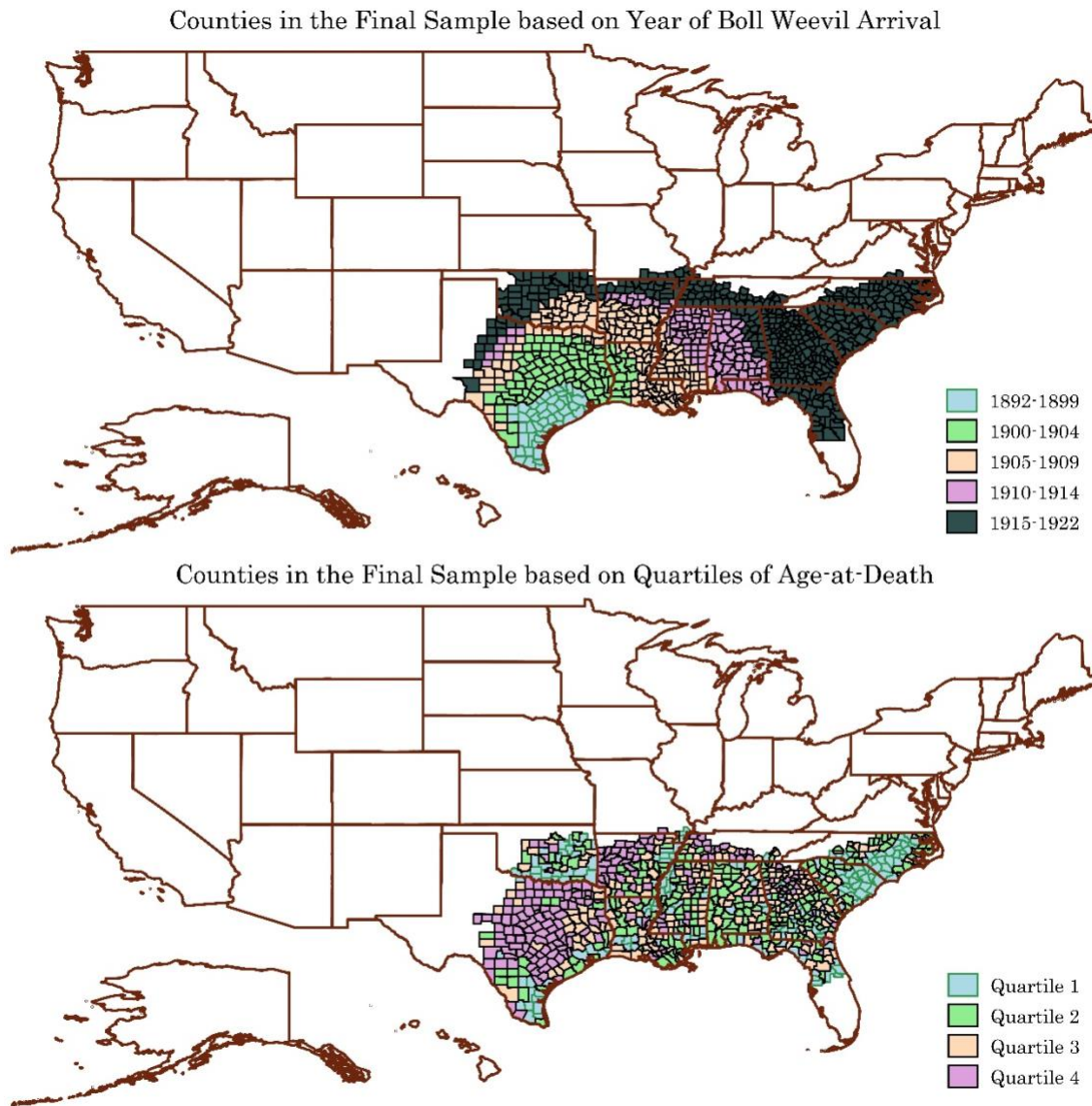


Figure 1 - Geographic Distribution of Arrival of boll weevil and Longevity across Affected Counties

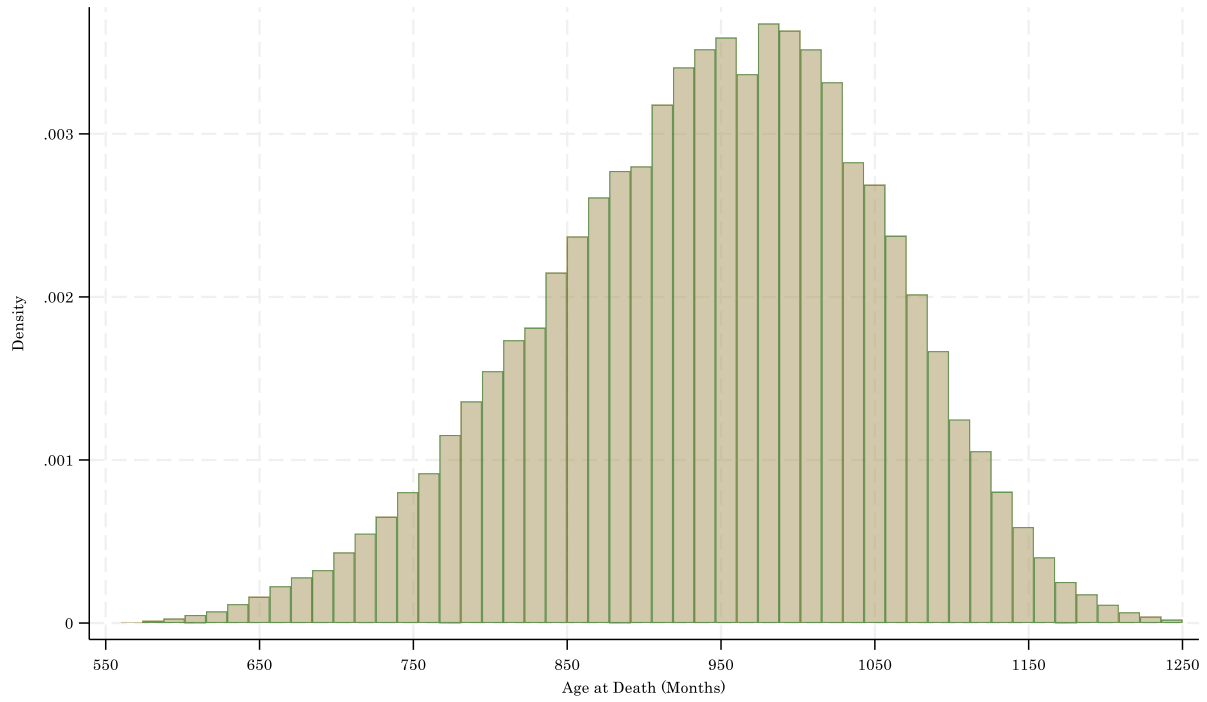


Figure 2 - Density Distribution of Age-at-Death in the Final Sample

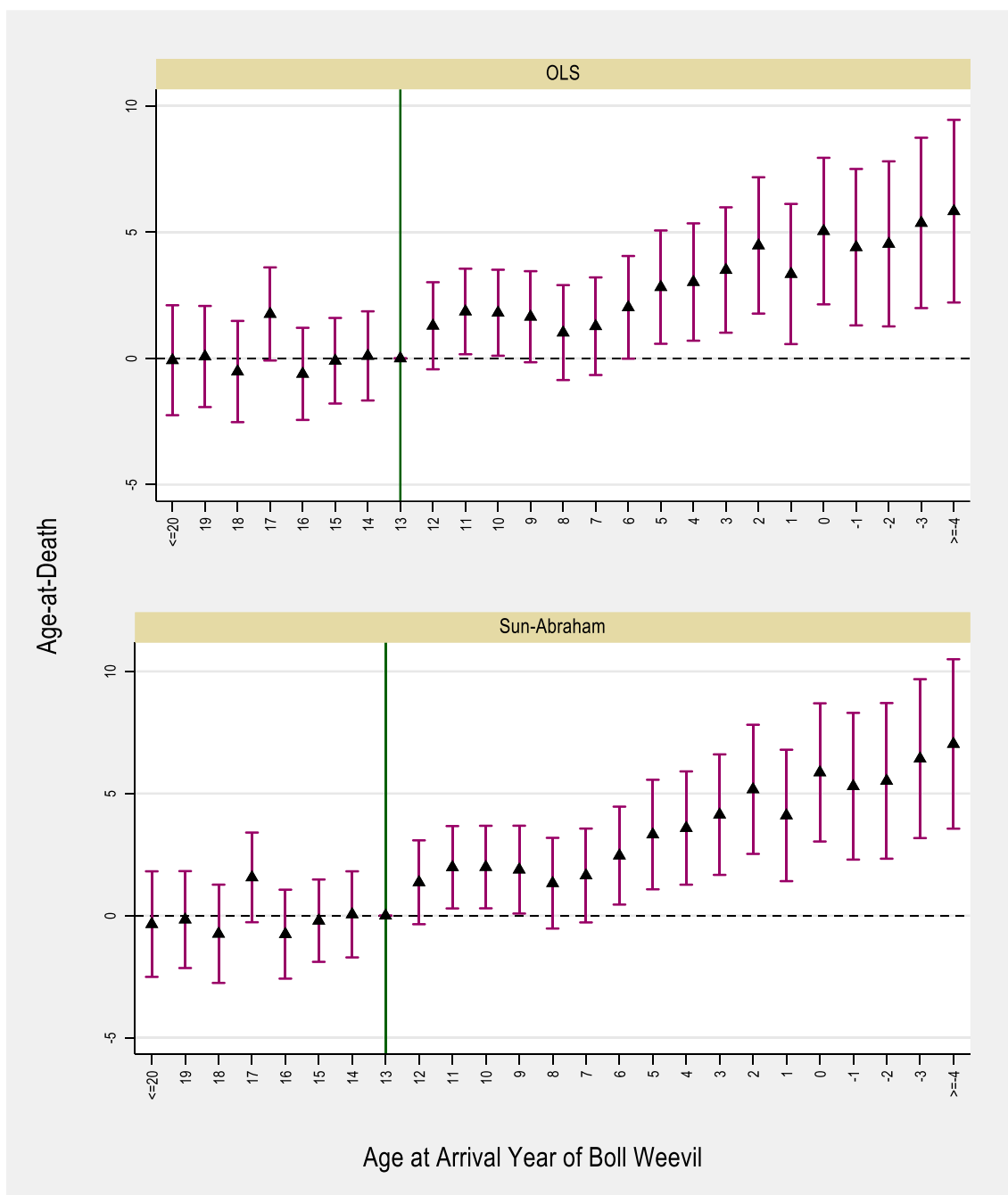


Figure 3 - Event Study Analysis to Examine the Effects of Childhood Exposure to Boll Weevil on Later-Life Longevity

Notes. Point estimates and 95% county-clustered confidence intervals are illustrated. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include share of homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in manufacturing sector, per capita workers in mining sector, per capita workers in construction sector, per capita workers in transportation sector, per capita farmers, and share of married.

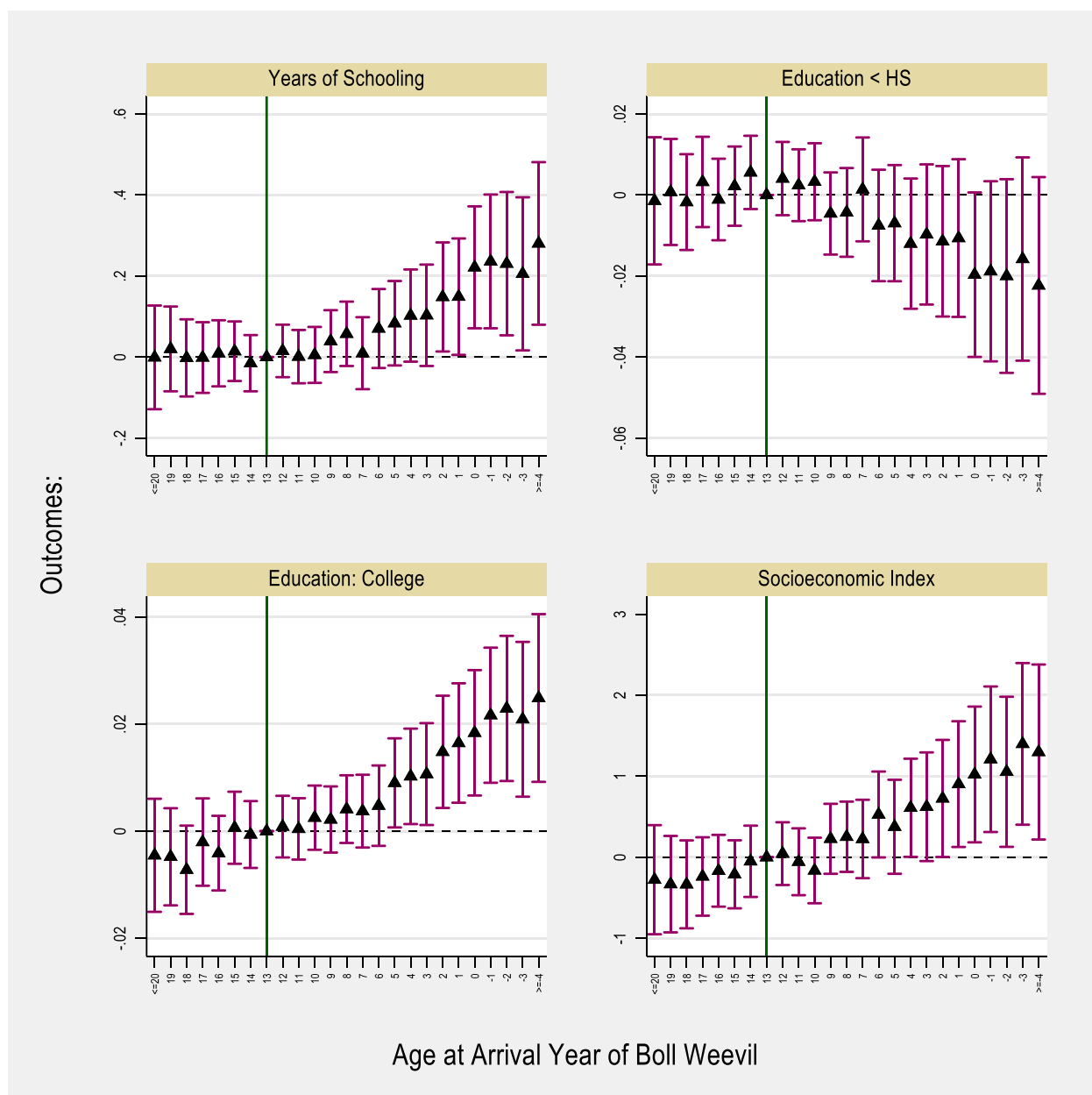


Figure 4 - Event Study Analysis to Examine Mechanism Channels between Childhood Exposure to Boll Weevil on Later-Life Longevity

Notes. Point estimates and 95% county-clustered confidence intervals are illustrated. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include share of homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in manufacturing sector, per capita workers in mining sector, per capita workers in construction sector, per capita workers in transportation sector, per capita farmers, and share of married. The sample is restricted to individuals above age 18.

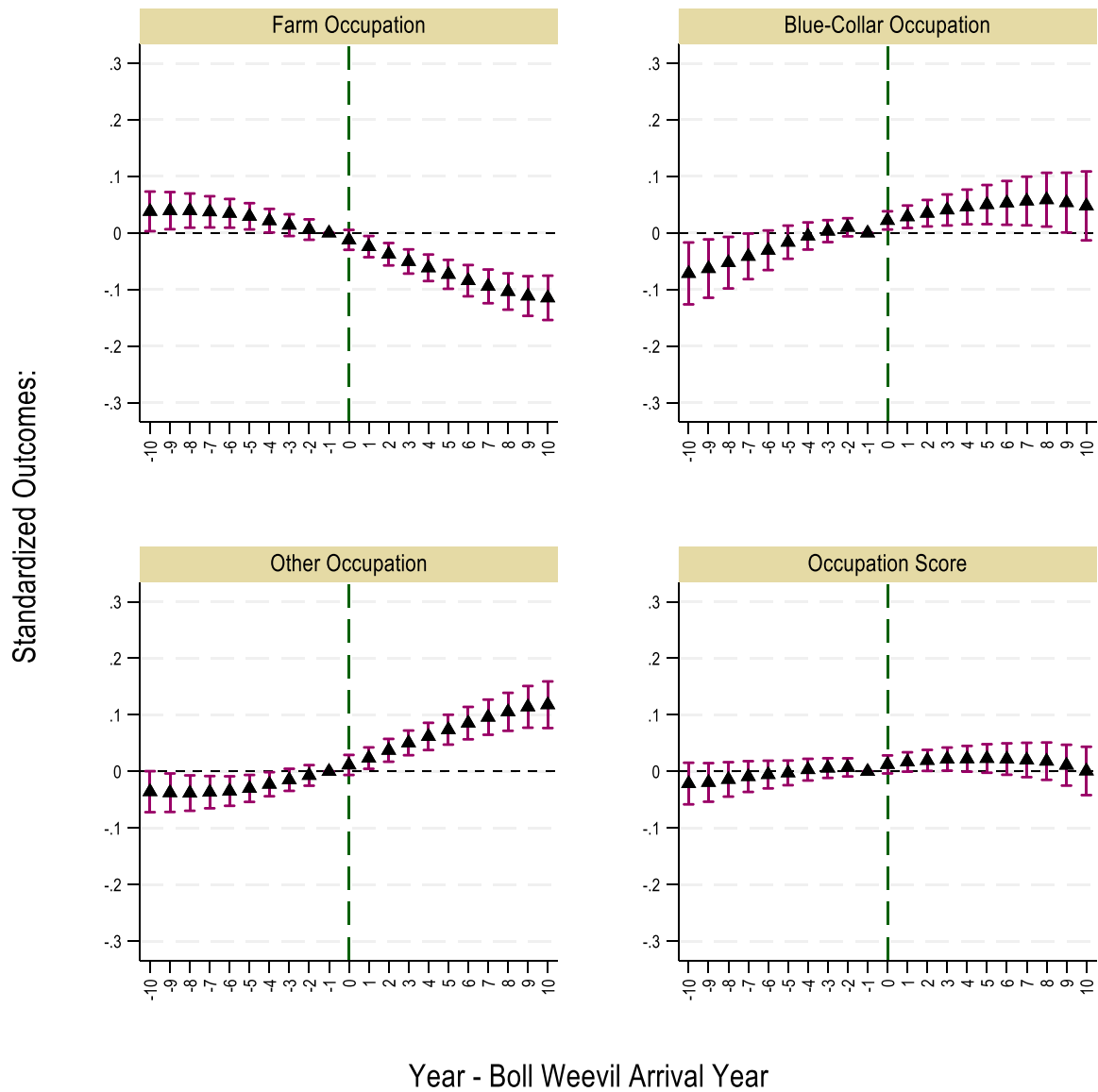


Figure 5 - Event Study Analysis to Examine the Evolution of County Characteristics in Years Before and After the Arrival of Boll Weevil

Notes. Point estimates and 95% confidence intervals are depicted. All regressions include county and year fixed effects. Regressions are weighted using county level population. The county by year panel is extracted from decennial censuses 1890 – 1940 and interpolated for inter-decennial years.

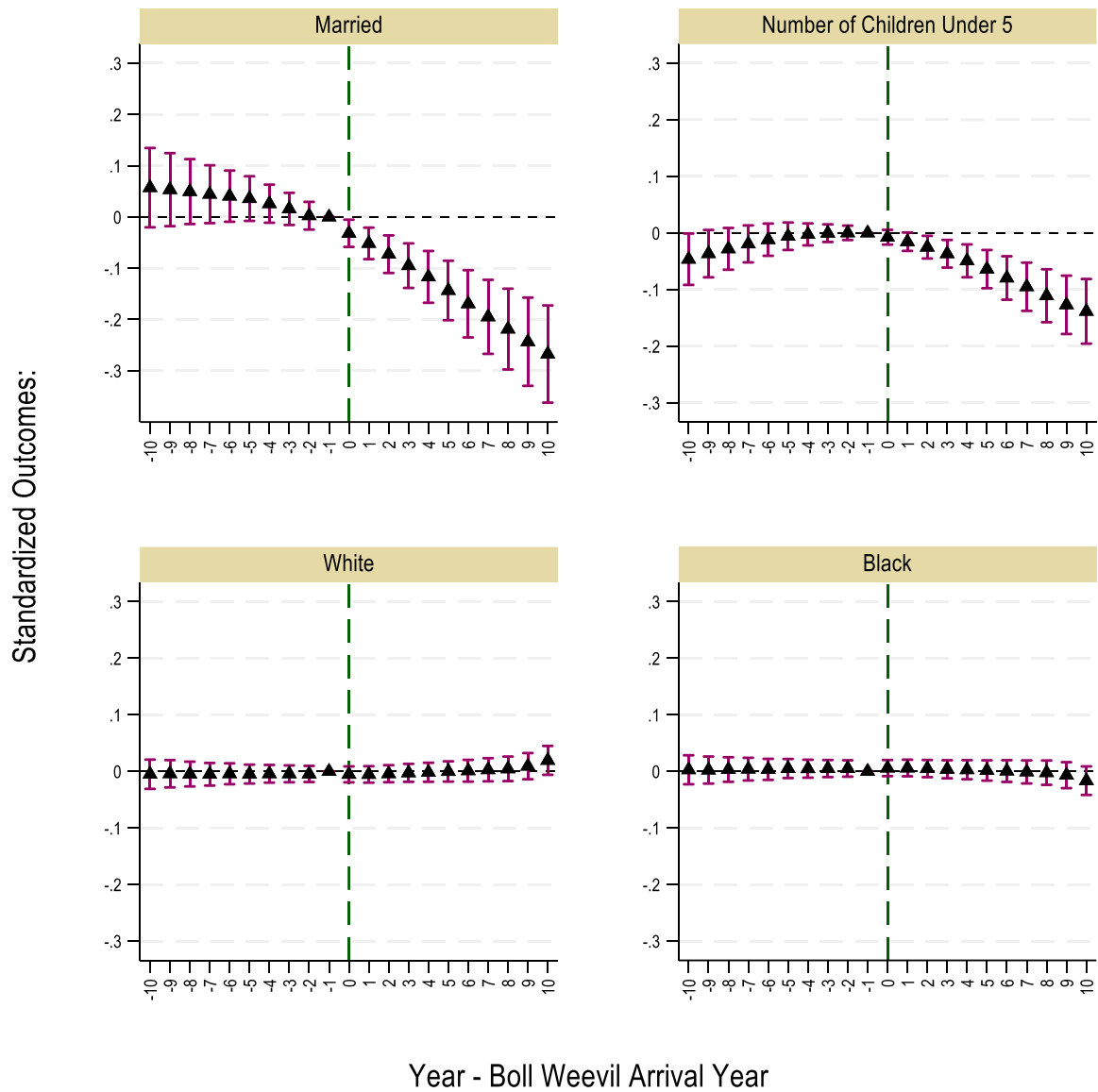


Figure 6 - Event Study Analysis to Examine the Evolution of County Characteristics in Years Before and After the Arrival of Boll Weevil

Notes. Point estimates and 95% confidence intervals are depicted. All regressions include county and year fixed effects. Regressions are weighted using county level population. The county by year panel is extracted from decennial censuses 1890 – 1940 and interpolated for inter-decennial years.

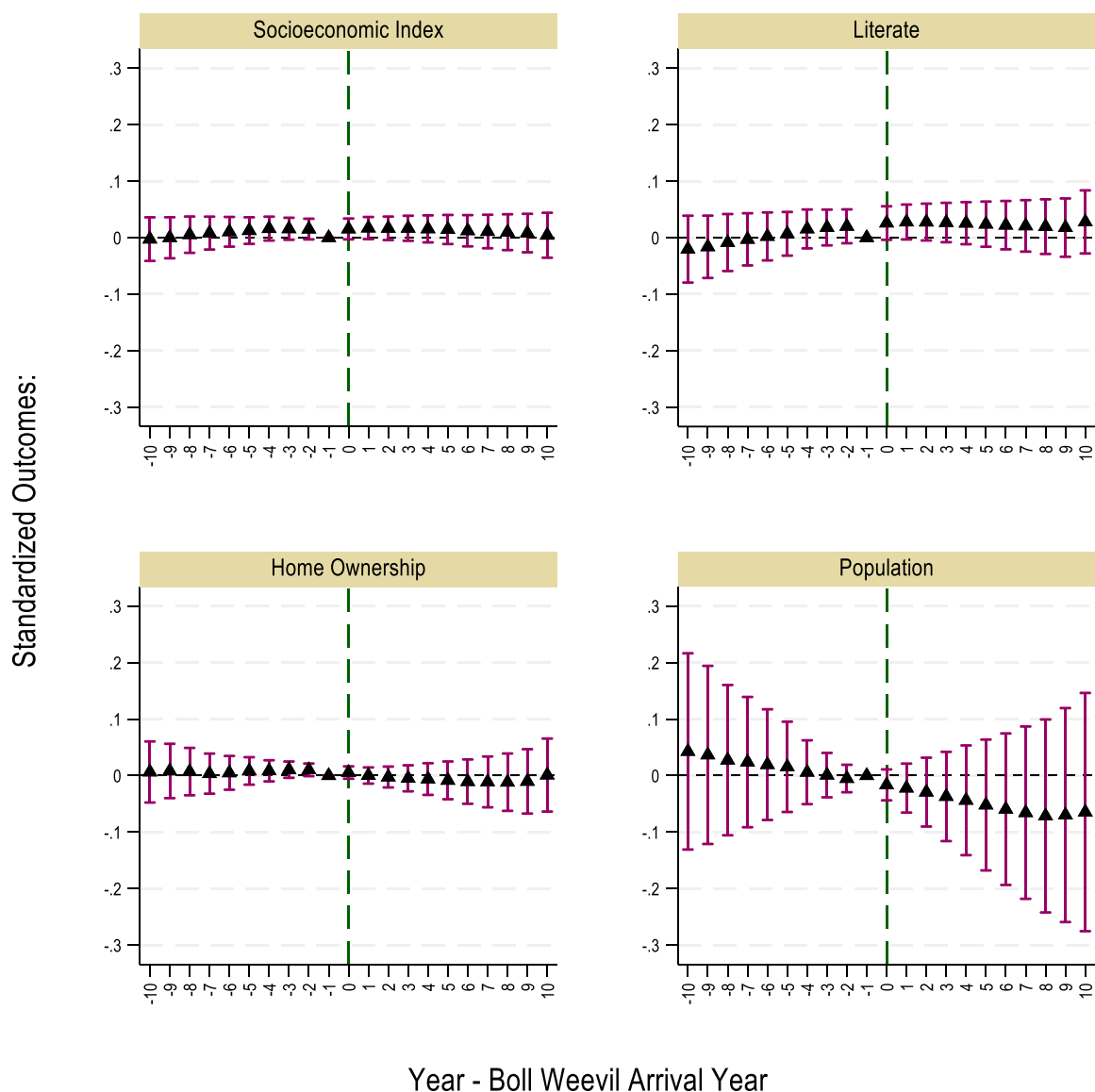


Figure 7 - Event Study Analysis to Examine the Evolution of County Characteristics in Years Before and After the Arrival of Boll Weevil

Notes. Point estimates and 95% confidence intervals are depicted. All regressions include county and year fixed effects. Regressions are weighted using county level population. The county-by-year panel is extracted from decennial censuses 1890-1940 and interpolated for inter-decennial years.

Appendix A

Appendix Table A-1 reports selected summary statistics in the final sample (first panel) versus the original population of 1940 whose early life county was in the Cotton Belt and who belong to birth cohorts of 1890-1940 (second panel). We observe a higher share of whites and a lower share of Blacks in the final sample compared with the original population. Breen & Osborne (2022) suggest that Although the DMF data overrepresents white populations and underrepresents Blacks, black and white subpopulations contain fairly similar characteristics as those in the original 1940 census population. As we look at other statistics related to maternal education and paternal socioeconomic status, we observe comparable values in the final sample to the original population.

Next, we empirically examine the association between exposure and successful data linking. In so doing, we merge the final sample (left panel of Appendix Table A-1) to the original population (right panel of Appendix Table A-1) and generate a dummy variable indicating successful merging. We then regress the merging indicator on exposure measure, conditional on county and birth year fixed effects. The results are reported in Appendix Table A-2. Exposed individuals are more likely to be in the final sample. However, the estimated coefficient is extremely small and statistically insignificant, suggesting a change of 0.5% with respect to the mean. We also observe small and insignificant coefficients when we look at subsample of whites and nonwhites (columns 2-3).

Appendix Table A-1 - Comparing Characteristics of the Final Sample with Original Population of 1940 Census

	<i>Final sample</i>		<i>Original population</i>	
	Mean	SD	Mean	SD
Birth year	1909.07	8.74	1906.91	9.56
White	.78	.41	.69	.46
Black	.22	.41	.3	.46
Year of boll weevil's arrival	1913.12	6.41	1913.35	6.37
Exposure share	.56	.5	.46	.5
Mother education less than high school	.2	.4	.16	.37
Mother education high school	.05	.22	.04	.19
Mother education college	.01	.11	.01	.1
Mother education missing	.74	.44	.79	.41
Father socioeconomic status first quartile	.05	.22	.04	.21
Father socioeconomic status second quartile	.09	.29	.07	.26
Father socioeconomic status third quartile	.02	.14	.01	.12
Father socioeconomic status fourth quartile	.05	.21	.04	.19
Father socioeconomic status missing	.79	.41	.83	.37
<i>County covariates:</i>				
Share of homeowners	.42	.13	.4	.13
Number of under-five children	.66	.16	.66	.16
Share of immigrants	.02	.05	.02	.05
Occupational income score	17.77	2.7	17.64	2.68
Per capita literate	.83	.11	.82	.11
Per capita employed	.6	.09	.61	.1
Per capita workers in manufacturing sector	.08	.08	.08	.07
Per capita workers in mining sector	.01	.04	.01	.04
Per capita workers in construction sector	.03	.02	.03	.02
Per capita workers in transportation sector	.04	.04	.04	.04
Per capita farmers	.25	.11	.25	.11
Share of married	.6	.04	.6	.04
Observations	734,375		5,801,422	

Notes.

Appendix Table A-2 - Examining the Association Between Exposure to boll weevil and Successful DMF-Census Merging

	<i>Outcome: successful merging between DMF (final sample records) and 1940 census, Subsamples:</i>		
	Full sample	Whites	Nonwhites
	(1)	(2)	(3)
Exposure Share	.00067 (.00098)	.00113 (.00116)	-.00165 (.00107)
Observations	5801422	4019388	1782034
R-squared	.02187	.01849	.01579
Mean DV	0.127	0.143	0.091

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Appendix B

Gutmann (2005) reports county-level agricultural production data for a limited number of counties in decennial years. We restrict the sample to the years between 1890-1940 and counties in the Cotton Belt. Based on the county-specific year of arrival of the boll weevil, we generate a dummy variable indicating post-weevil years. We then regress cotton production (in bales) on the post-weevil dummy, conditional on county and year fixed effects. The results are reported in Appendix Table B-1. We observe significant reductions in cotton production. In the years following the arrival of the boll weevil, cotton production dropped by roughly 55%. Although there are changes in the production of other crops, the estimated coefficients remain comparably small and statistically insignificant.

Appendix Table B-1 - Examining the Effects of County Exposure to boll weevil and Agricultural Productions

	<i>Outcomes:</i>			
	Log cotton production (bales)	Log barley production (bales)	Log rye production (bales)	Log Pea/Bean production (bales)
	(1)	(2)	(3)	(4)
Post boll weevil	-.54629*** (.15698)	-.15373 (.31578)	.01442 (.392)	-.27668 (.20518)
Observations	1312	588	565	705
R-squared	.77073	.76648	.67377	.7703
Mean DV	8.263	6.811	5.676	5.723

Notes. Standard errors, clustered on county, are in parentheses. All regressions include county and year fixed effects. Regressions are weighted using share of farmland in the county in 1900.

*** p<0.01, ** p<0.05, * p<0.1

Appendix C

In this appendix, we complement the analysis regarding balancing test of Table 6. Specifically, we examine changes in socioeconomic and sociodemographic characteristics of individuals in the 1940 census (prior to merging with the DMF data) as a function of boll weevil exposure in regressions similar to equation 2. The results are reported in Appendix Table C-1. We find significant increases in the share of whites and increases in the share of Blacks. However, the implied change with respect to the mean is extremely small (0.8%). In addition we do not observe any significant change in parental characteristics.

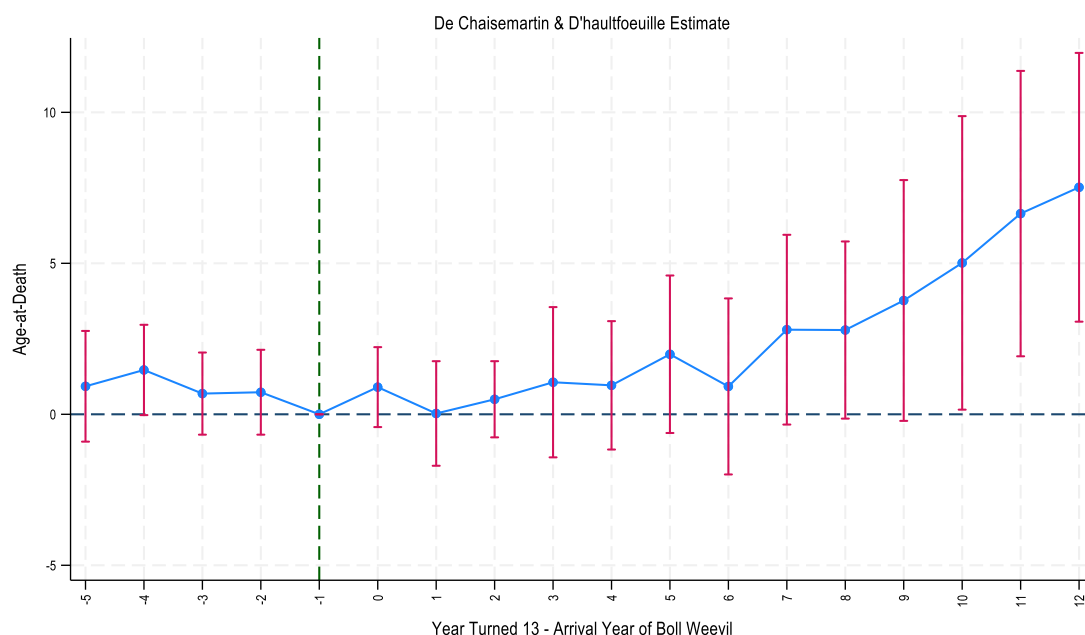
Appendix Table C-1 - Examining Changes in Sociodemographic and Socioeconomic Composition Due to Childhood Exposure to Boll Weevil Using the Full-Count 1940 Census

	<i>Outcomes:</i>					
	White	Black	Father socioeconomic index	Father socioeconomic index missing	Mother literate	Mother literacy missing
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure Share	.00628*** (.00149)	-.00635*** (.00144)	-.01619 (.06888)	-.00378 (.00286)	.00012 (.0026)	-.00395 (.00288)
Observations	6110549	6110549	4396499	6110549	6110549	6110549
R-squared	.17472	.17783	.06652	.07969	.07799	.06915
Mean DV	0.694	0.303	19.852	0.281	0.639	0.256

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects and birth year fixed effects.

*** p<0.01, ** p<0.05, * p<0.1

Appendix D



Appendix Figure C-1 - Event Study Analysis to Examine the Effects of Childhood Exposure to Boll Weevil on Later-Life Longevity Using De Chaisemartin & D’haultfoeuille (2020)

Notes. Point estimates and 95% county-clustered confidence intervals are illustrated. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include share of homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in manufacturing sector, per capita workers in mining sector, per capita workers in construction sector, per capita workers in transportation sector, per capita farmers, and share of married.

